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# The Emergence of Markets in the Natural Gas Industry

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Deregulation and restructuring of the natural gas industry in many countries has led to the development of new markets that have changed how the industry operates. A growing number of countries — including the United States, the United Kingdom, and Argentina — are reforming their gas sectors to increase competition and develop new models of interaction among participants. A number of models and lessons of reform are available to other countries interested in reforming their natural gas industry.



## Summary findings

As countries have deregulated prices and lowered entry barriers in the natural gas industry, many new participants have emerged, promoting competition in the newly created markets. The increased competition has benefited everyone through more efficient pricing and greater choice among natural gas contracts.

Four distinct structural models have emerged in the industry's restructuring. The traditional model (a vertically integrated industry) has been increasingly replaced by models that decentralize the industry along horizontal and vertical lines.

With increasing decentralization, regulation of the industry focuses on pipeline transportation and distribution, the industry segments with natural monopoly characteristics. Regulation aims to protect both end users and participants in the deregulated segments from the market power of companies operating in the monopolistic segments.

As a result of deregulation, two major markets emerge: the natural gas market (which facilitates the trading of natural gas as a commodity) and the transportation market (which enables market participants to trade the services needed to ship natural gas through pipelines).

Competition and open entry are crucial for these two markets to function efficiently. The transportation market is affected by the market power of pipeline companies, but resale of transportation contracts brings competition to this market and facilitates the efficient allocation of contracts. Intermediaries and spot markets promote efficient pricing and minimize transactions costs.

Markets have become more complex with deregulation, and trading mechanisms are needed to ensure the simultaneous clearing of natural gas and transportation markets at minimum cost to the industry. Two main trading models guide transactions: the bilateral trading model (which relies on decentralized bilateral negotiations between market participants) and the poolco model (which relies on a centralized entity to coordinate transactions).

Properly applied, both models lead to the same outcome. The bilateral trading model has dominated because of its simplicity of implementation, but the poolco model has great potential once problems of sharing and processing information are addressed.

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This paper — a product of the Private Participation in Infrastructure Group, Private Sector Development Department — is part of a larger effort in the department to analyze issues arising from private participation in infrastructure. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Sandra Vivas, room Q7-005, telephone 202-458-2809, fax 202-522-3481, Internet address [svivas@worldbank.org](mailto:svivas@worldbank.org). March 1998. (37 pages)

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**THE EMERGENCE OF MARKETS**

**IN**

**THE NATURAL GAS INDUSTRY**

**Andrej Juris**

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The deregulation and restructuring of the natural gas industry in many industrial and developing countries have led to the development of new markets that have altered the way the industry operates. As countries have deregulated prices and lowered entry barriers in the industry, many new participants have emerged, promoting competition in the newly created markets. The increased competition has benefited all participants in the natural gas industry—through more efficient pricing and greater choice of natural gas contracts.

Four distinct structural models have emerged in the restructuring of the natural gas industry, with the traditional model of a vertically integrated industry increasingly replaced by models that decentralize the industry along horizontal and vertical lines. These models introduce greater competition and new models of interaction among market participants, and they reflect how far a country has advanced in its reform of the natural gas industry. With increasing decentralization, regulation of the industry focuses on pipeline transportation and distribution, the industry segments with natural monopoly characteristics. The objective of regulation is to protect both the end users and the participants in the deregulated segments from the market power of companies operating in the monopolistic segments.

Two major markets emerge as a result of deregulation: the natural gas market, which facilitates the trading of natural gas as a commodity, and the transportation market, which enables market participants to trade the transportation services necessary to ship natural gas through the pipeline system. Competition and open entry are crucial for the efficient functioning of these two markets. Although the transportation market is affected by the market power of pipeline companies, resale of transportation contracts introduces competition in this market and facilitates the efficient allocation of contracts. Intermediaries and spot markets promote efficient pricing and minimize transaction costs.

With increasing deregulation, markets become more complex, and trading mechanisms are needed to ensure simultaneous clearing of natural gas and transportation markets at the minimum cost to the industry. Two main trading models achieve this socially optimal outcome: the bilateral trading model, which relies on decentralized bilateral negotiations between market participants to reach this outcome, and the poolco model, which relies on a centralized entity that coordinates individual transactions.

If properly applied, both models lead to the same outcome. The bilateral trading model has been the dominant model used in the gas industry, however, because of its simplicity in implementation. But the poolco model has great potential once problems with sharing and processing information are adequately addressed.

This paper outlines the main characteristics of the deregulated natural gas industry. It provides an overview of the main determinants and models of industry structure and the basic principles of economic regulation in the natural gas industry. It describes markets that have emerged as a result of deregulation and looks at new markets in storage, metering, pipeline construction, and system balancing. Finally, it outlines the mechanics of bilateral trading and “poolco” models, which guide transactions in the natural gas industry. Two companion papers give case studies of

natural gas deregulation in the United Kingdom and the United States (Juris forthcoming a and b).

## **Opening the Gas Industry to Competition**

Many countries have undertaken substantial structural and regulatory changes in their natural gas industries in recent years opening natural gas and pipeline transportation markets to competition. Since 1984 the United States has separated natural gas supply from interstate pipeline transportation, deregulated natural gas production and the wholesale market, and introduced competition in interstate pipeline transportation. Another major reformer, the United Kingdom, partially opened its natural gas market to competition in 1986, when the government privatized British Gas.

The United Kingdom continued deregulation by further opening the wholesale natural gas market and promoting the natural gas resale. The most recent measures are aimed at fully separating pipeline transportation from supply and gradually introducing competition in the retail market. By 1998 the United Kingdom should have the most competitive natural gas industry in the world.

Other countries have followed the lead of these two reformers. Argentina undertook a radical reform of its gas industry in 1992, when it separated and then privatized natural gas production, transportation, and distribution. Distribution companies and large end users can now purchase natural gas directly from producers, bypassing the resale units of pipeline transportation companies. Mexico opened its natural gas market to competition in 1993, and Hungary separated and privatized distribution companies in 1994-95.

Many other countries in Asia, Europe, and Latin America too would like to reform their natural gas industries to improve efficiency and attract new investment. These countries stand to benefit a great deal from the lessons learned by reform countries.

A government that wants to reform the natural gas industry faces a complex task. It needs to assess the viability of competition in the industry as a whole and in its segments, identifying those with natural monopoly characteristics. And it needs to formulate optimal regulatory policies and introduce mechanisms to support efficient interactions between regulated and deregulated segments of the industry.

### **Determinants of industry structure**

The viability of competition in the natural gas industry is determined by three factors: technology, the size of the market, and entry barriers. Technology determines economies of scale and scope and thus a firm's optimal (or minimum efficient) size. The size of a market determines how many firms can efficiently compete in it. Entry barriers determine whether an additional firm can enter the market, if the opportunity to do so exists. These three underlying factors determine the efficient configuration of the industry in a static model.

A dynamic model of the natural gas industry incorporates changes in the underlying factors to reflect the dynamics of the environment in which the industry participants operate. Technological development, uncertainty about supply and demand, and regulatory changes influence the

viability of competition in the industry in the long run. The viability of competition must be assessed separately for each segment of the natural gas industry, because participants use different technologies in each segment.

The natural gas industry consists of the following segments: production, pipeline transportation, trading and supply, and distribution. In the reform countries production and trading and supply are potentially competitive, while transportation and distribution are characterized by natural monopoly.

Natural gas production consists of the large set of operations necessary to deliver natural gas to the wellhead, such as exploration, drilling, production, and gathering. Gathering is the aggregation of natural gas produced by individual wellheads and its delivery to a location such as a terminal, where it is injected into a pipeline. It is usually considered part of the production, because producers often own and operate gathering pipelines. Production is characterized by multiproduct scale economies across the whole set of operations at the firm level, but these scale economies typically are not large enough to eliminate competition at the industry level. Producers must incur substantial fixed start-up costs, much of it sunk, first in the acquisition of drilling rights and technology and then in exploration and drilling. Only then can a producer start producing natural gas. It is more feasible for one firm to carry out both exploration and drilling than to separate these tasks because of the uncertainty in searching for natural gas. As a result, the optimal size of a production firm is large, though still small relative to the natural gas market. There are more than 100 natural gas producers in the United States, and more than 40 in the United Kingdom.

Natural gas trading refers to the resale of natural gas in the wholesale market, and supply to resale in the retail market. (In the United States gas trading and independent gas supply are considered part of marketing.) Because these two operations are closely related, they are often performed by the same firm. The gas trading and supply business is a very competitive segment because of the limited scale economies. Traders and suppliers need little up-front investment to start operations—a trader needs only a desk, a computer, and a telephone to contact customers and make deals. As a result, the optimal size of a gas trader or supplier is small relative to the gas market. This optimal size increases with deregulation of the industry—because markets become more complex, with increasing use of short-term and financial transactions—but not enough to pose a threat to competition in the segment.

Natural gas transportation is the set of operations to deliver natural gas from a producer to consumer markets through high-pressure pipelines. The transportation segment is characterized by natural monopoly because of the large multiproduct economies of scale resulting from the high fixed costs of pipeline construction. Most of the fixed costs are sunk because a pipeline has limited alternative uses. Operating costs are relatively low, because it costs little to move natural gas through pipelines. There are also economies of scale associated with the multiproduct characteristics of transportation services. A pipeline company can use the same pipeline system to offer transportation services that differ in time, location, and other dimensions (such as the calorific value of natural gas and the intake and offtake pressure of the pipeline). As a result, only



one pipeline company can typically operate in the transportation segment, although large markets can accommodate several pipeline companies.

Natural gas distribution consists of the operations necessary to deliver natural gas to the end users, including low-pressure pipeline transportation, supply of natural gas, metering, and construction of customer sites. Distribution is characterized by natural monopoly because of economies of scale in transportation operations. Additionally, there are economies of scope among various operations of a distribution company, because they are performed by the same distribution pipeline system. It is still unclear whether the economies of scope are large enough to prevent efficient unbundling of transportation and supply operations at the distribution level. But open access to distribution does seem to generate sufficient competition in supply to large end users.<sup>1</sup> Distribution companies typically enjoy exclusivity in natural gas supply in their region, but an increasing number of countries have instituted open access in distribution.

### **Regulate or not?**

Natural monopoly in pipeline transportation and distribution calls for economic regulation to prevent the incumbent utility from exercising its market power. The main goal of economic regulation is to promote economic efficiency. Regulators often pursue additional goals, such as fairness or transparency, but these should complement rather than substitute for the economic efficiency goal. Economic regulation employs various mechanisms to regulate the prices of goods and services, the performance of regulated firms, and market entry.<sup>2</sup>

Two well-known and widely used regulatory mechanisms are rate-of-return regulation and price caps. Rate-of return regulation allows the regulated utility to set rates for natural gas such that it earns no more than a predetermined rate of return on its capital. The regulator approves the rates and the size of the capital base that is used for calculating rate of return, and prohibits entry in the utility's line of business. The targeted rate of return is typically set equal to the rate of return on capital facing the same risk as the utility's capital. The utility is assured of earning the targeted rate of return because the regulator typically allows a pass-through of cost increases to the end user rates.<sup>3</sup>

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<sup>1</sup> Introduction of open access in distribution had positive results in Argentina, the United Kingdom, and the United States, where end users benefited from lower prices and greater choice. But pilot programs in retail competition showed that a local distribution utility can exercise market power through its control of system operation, metering, or billing. So the benefits of unbundling distribution must be weighed against the costs of potential exercise of market power and of regulation of distribution.

<sup>2</sup> There is a whole body of literature on the theory of optimal regulation and pricing. See Berg and Tschirhart 1988, Braeutigam 1989, or Laffont and Tirole 1993.

<sup>3</sup> The actual rate of return earned by a utility does not always reach the predetermined level because of regulatory lag, the time between the cost increase and the regulatory decision that approves cost pass-through. In such a case the regulator asks the utility to adjust its rates so as to recover the difference between the actual and targeted rates of return in the subsequent period. A utility regulated by rate-of-return regulation seldom achieves the targeted rate of return in very dynamic markets.

Price cap regulation sets the maximum price that a natural gas utility can charge its customers for a certain period. After this time, typically three to five years, the regulator reviews the welfare impact of the price cap and determines a new price cap. The utility cannot increase its revenues by charging more than the price cap, but it is free to minimize its costs. Since cost cutting could occur at the expense of safety and reliability, the regulator sets well-defined safety and reliability standards for the utility. So the incentive for the utility is to operate efficiently.<sup>4</sup> All changes in input costs are absorbed by the utility until the price cap review, unless the regulator allows a pass-through of some costs (for example, fuel costs).

The economic efficiency goal of regulation implies that the regulated prices of pipeline transportation or distribution services must reflect their economic costs and maximize social welfare. This does not necessarily mean that regulators must always set prices administratively. Instead, whenever possible, regulators should adopt pricing concepts that give a utility incentives to set optimal prices for transportation and distribution services. Such concepts as peak-load pricing, Ramsey pricing, and nonlinear pricing promote efficient pricing and benefit all industry participants.

If competition is viable in natural gas production and trade and supply, prices and entry should be deregulated to promote efficient markets. If producers, traders, and suppliers are restricted in their ability to set prices or enter the market, some participants will acquire enough market power to sustain high prices. Without price arbitrage or entry to discipline incumbent companies, other market participants incur welfare losses.

Small countries often have limited competition in their natural gas markets, because the markets are not large enough to support efficient operation by a large number of domestic producers or suppliers. In these countries regulators should focus on lowering entry barriers rather than on regulating domestic firms. If entry barriers are low, the threat of entry by foreign competitors can serve as an effective check on domestic market participants.

### **Structural models of the natural gas industry**

The more than 10 years of deregulation have produced new structural models of the natural gas industry. Traditional vertical integration is being replaced by de-integration along both vertical and horizontal lines. The most important structural changes in the gas industry are open access — opening the pipeline transportation segment to third-party transportation — and unbundling — separating natural gas supply from pipeline transportation. These changes have led to four distinct structural models of the natural gas industry.

#### *Vertical integration*

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<sup>4</sup> Formulation of the price cap is very important in determining the efficiency of incentives faced by the utility. For example, a price cap equal to the weighted average price of all services offered by the utility can harm the utility or its customers if consumption of services varies a lot. It also neglects the issue of how new services should be regulated. Setting price caps for individual services equal to their stand-alone costs gives the utility more efficient incentives than a price cap based on a weighted average price.

Model 1 is the traditional structure of the natural gas industry, where production, pipeline transportation, and distribution are all performed by one company, an integrated gas utility (figure 1). Typically, such a utility has an exclusive position in natural gas supply to end users, that is, in the retail market. An example is Gazprom, the Russian gas company, which is engaged in all segments of the industry.

An integrated gas utility is usually heavily regulated because of its monopoly position in the retail market. The regulatory agency typically uses rate-of-return or price cap regulation to promote economic efficiency and restrict the utility's market power.

A vertically integrated utility lacks the flexibility required in a dynamic market environment, and regulation is often insufficient to induce it to operate efficiently. Governments seeking alternative industry configurations that would address these problems have identified several areas with good potential for cost savings: production, wholesale transactions, and retail transactions.

#### *Competition in natural gas production*

Model 2 separates production from the rest of the industry and introduces competition among producers, resulting in more efficient production than in model 1 (figure 2). Producers sell natural gas to a gas utility, which then resells it to the end users. The transactions between the producers and the utility lead to the development of a wholesale natural gas market, where natural gas is traded for further resale. A typical example of a model 2 gas utility is British Gas prior to its privatization in 1986; before it was privatized, it purchased natural gas from more than 40 producers.

In model 2 regulation is needed to restrict the market power of the gas utility relative to both the end users and the producers. End user prices are regulated in the same way as in model 1. The price of gas sold by producers to the utility is also regulated. But the optimal way to determine a purchase price is through competitive bidding, in which producers bid by price for a supply contract with the gas utility. A price determined through competition reflects the market value of natural gas far better than does a price set by a regulator.

Monopolistic gas utilities can often prevent the pass-through of cost savings in production to end users because of distortive regulation or an ability to exercise market power. Governments therefore seek ways to open pipeline transportation and distribution to competition.

#### *Open access and wholesale competition*

Model 3 introduces open access in pipeline transportation, opening the segment to third-party transportation (figure 3). In this model a gas utility thus provides two kinds of service: supplying natural gas to end users and supplying transportation services to large end users and other eligible industry participants that purchase natural gas independently in the wholesale market. Alternatively, a gas utility is separated vertically into a pipeline company and several distribution

utilities, and they provide open access to their pipeline networks.<sup>5</sup> The gas industry in the United States between 1985 and 1992 was a typical example of the model 3 gas industry, as was the U.K. gas industry before British Gas was unbundled into a gas supplier and a pipeline operator in 1996.

The open access regime promotes efficiency in the wholesale gas market and benefits market participants. Producers benefit because open access dramatically increases the number of buyers, eliminating the monopsony problem in model 2. Downstream industry participants, such as distribution utilities or large end users, benefit from direct access to the production segment and a greater choice in gas supply.

But pipeline companies are in a more difficult position than in models 1 and 2 because they have to coordinate transportation of their own and third-party natural gas through the pipeline network. This coordination can be achieved by introducing market mechanisms that optimize interactions among market participants and the operation of the pipeline system in deregulated natural gas markets. Such coordination can be facilitated by the trading mechanism described in the section below on trading models.

Transactions in the wholesale natural gas market are typically conducted on a bilateral basis, but increasing complexity calls for intermediation of these transactions. The acquisition of natural gas and transportation services is often complex, and for some market participants it may be too difficult and costly. High transaction costs discourage smaller market participants from utilizing open access, despite opportunities for cost saving. This creates room for natural gas traders, which aggregate demand and supply for a number of smaller market participants by purchasing natural gas and transportation services on their behalf. Traders charge fees for intermediating transactions and minimize the costs of natural gas and transportation services by buying large quantities and arbitraging across available prices. Competition among traders is crucial to minimize their fees and to maximize the benefits for their clients.

There are three important regulatory tasks in the model 3 gas industry: to protect end users from the monopoly power of gas utilities, to promote competition in the wholesale gas market, and to restrict the market power of pipeline companies relative to the users of their pipeline networks. End user prices are regulated, using rate-of-return or price gap regulation. Wholesale gas prices are deregulated if there is sufficient competition in the market. If competition is limited, regulators should focus on removing entry barriers rather than on directly regulating prices, because regulating wholesale prices does not promote the development of competitive trading.

The price of a transportation service, or the access price, is one of the most important factors in achieving competition and efficiency in the wholesale market. The reason is that unregulated

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<sup>5</sup> There are many variations on the open access regime, depending on the pressure level at which pipelines are subject to open access. Determining the threshold level is important in ensuring optimal investment in the gas industry. If the threshold is too high, many large end users find it cost-effective to bypass low-pressure, non-open-access pipelines by constructing a connection to a pipeline that makes them eligible for open access. This may result in overinvestment in pipelines.

pipeline companies can charge excessive access prices or foreclose access to maintain their monopsony power. One way to determine an optimal access price is through the efficient component pricing rule, which says that the access price must recover the pipeline's costs of providing transportation services to a third party and the pipeline's profits forgone in gas supply operations lost to competition. This price gives a pipeline company the right incentives to provide open access, while it ensures that only those users that paid less for wholesale natural gas than the pipeline company will consume transportation services.

### *Unbundling and retail competition*

Model 4 introduces unbundling—the separation of natural gas supply from pipeline transportation and distribution—and full deregulation of natural gas markets (figure 4). The main motivation for unbundling is an ability by pipeline companies to restrict competition in the wholesale gas market through nonprice measures, such as offering low-quality transportation services.

Unbundling eliminates this distortion and creates a level playing field for all participants in the natural gas market. In addition, it facilitates the development of a large number of supply companies that purchase natural gas in the wholesale market, resell it downstream, and use the transportation services of pipeline and distribution companies. Competition among supply companies pushes down their resale markups and thus facilitates the pass-through of cost savings from the production segment to the end users.

Increasing competition in and deregulation of the natural gas market eliminate the need for price regulation at the wholesale level and call for regulatory mechanisms that give gas companies more pricing flexibility at the retail level. Rate-of-return regulation greatly restricts pricing flexibility and so is less optimal for model 4 than price cap regulation.

In model 4 the natural gas market undergoes significant transformation to accommodate the variable requirements of market participants, which seek more flexible trading and contractual arrangements than in model 3. Natural gas is increasingly traded through short term contracts to balance supply and demand in the short-term and give market participants the flexibility they need.

The development of a short-term, or spot, market promotes efficiency in the entire gas market. As a spot market becomes more liquid, the spot price moves toward the short-run marginal cost of gas, which reflects the market value of natural gas at the location of the spot market. Because prices are continuously determined in a liquid, competitive market, the pricing of natural gas becomes more efficient. Market participants use spot prices as a reference price in bilateral gas supply contracts, and so as a result, most natural gas is traded at spot prices.

Short-term gas trading generates volatility in volume and price, increasing the uncertainty of demand for transportation services. In some periods demand can exceed available capacity; in others, it may fall below constructed capacity. Pipeline companies respond by selling both firm contracts, which allow market participants to purchase transportation services with high

reliability, and interruptible contracts, under which market participants purchase services with low reliability. Pipelines also use gas flow management techniques to minimize swings in demand and maximize gas flows through the system.

Unbundling introduces a need for simultaneous clearing of natural gas and transportation markets. Market participants acquire natural gas based on the availability of transportation, and vice versa. A mismatch wastes resources, because some participants are left with excess natural gas or with reserved pipeline capacity that goes unused. A match can be achieved only when market participants have available the same volumes of gas supply and transportation contracts. This requires the creation of a short-term transportation market, where pipeline companies and transportation contract holders offer available capacity for sale. An alternative is to adopt a “poolco” trading mechanism that ensures simultaneous clearing of natural gas and transportation markets (see the section below on the poolco model).

Large variability in contracts increases the complexity of pricing transportation services. Although pipeline companies mostly maintain their market power, they need pricing flexibility to react to changing market conditions. Regulators should therefore use price caps or another regulatory mechanism that gives pipelines pricing flexibility while also promoting efficient relative prices.

No gas industry has developed to a full-scale model 4 structure. The United Kingdom should reach a model 4 structure in 1998 when it introduces full retail competition, however, and the U.S. natural gas industry is moving in this direction. Both countries have unbundled pipeline transportation and introduced open access in distribution—a typical configuration for a gas industry in transition from model 3 to model 4 (figure 5).<sup>6</sup> Open access in distribution is limited to end users with consumption of a certain size (2,500 therms a year in the United Kingdom), because the high costs of metering make competition nonviable in residential gas supply. In addition, an incumbent distribution company can discourage use of open access by offering low-quality or imprecise metering services to independent suppliers.

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<sup>6</sup> The United Kingdom and the United States also introduced retail competition on a small scale in some regions. For example, a pilot program gave 500,000 residential customers in the southeast of England an option to choose their natural gas supplier in 1996. Similar pilot programs were introduced in Pittsburgh, New Hampshire, and many other locations throughout the United States.

## **The Emergence of Markets**

A vertically integrated gas industry has only one market, where natural gas and transportation services are sold at the consumption site as a single product, or “bundle.” Open access and the unbundling of pipeline transportation have led to the creation of two main markets, where natural gas and transportation are traded separately.

Natural gas and transportation markets are divided into several submarkets, based on the characteristics of traded products. Product characteristics are determined by the dimensions of the contracts for natural gas supply and transportation, such as time of service, reliability of service, delivery location, type of financial settlement, and quantity and quality of natural gas. The variability in the contracts has led to the development of such submarkets as long-term and short-term markets and physical and financial gas markets.

The variability of contracts benefits industry participants because they can enter into contracts that best suit their needs. Each participant can form a contract portfolio that minimizes their costs and risks and maximizes their benefits. It is important that a participant’s choice not be distorted by regulation, which results in suboptimal contracting and imposes unnecessary transaction costs. Where competition has eliminated concerns about market power, regulators should put great effort into promoting decentralized contracting among market participants.

The opening of wholesale and retail markets to competition has initiated a search for “markets” in all segments of the natural gas industry. Some countries have introduced competition in storage, metering and installation of meters, construction of pipelines and customer sites, and pipeline system balancing.

### **Natural gas market**

In natural gas market natural gas is traded as a commodity, separate from transportation services, in the form of gas contracts. Although these contracts have multiple dimensions, they are differentiated primarily by the purpose of the transaction, whether for physical delivery of gas or for management of price risk. The use of contracts thus divides the gas market into two submarkets—physical and financial.

#### *Physical gas market*

In the physical gas market natural gas is traded under contracts for physical delivery of gas, physical gas contracts (sometimes referred to as cash gas contracts). Market participants include producers, traders, suppliers, pipeline companies, and distribution utilities, depending on the structural model of the gas industry. The physical gas market exists in all structural models, although natural gas is bundled with transportation in models 1 and 2. Two dimensions of physical gas contracts divide the physical gas market into several submarkets: the purpose of the transaction and the duration of the contract.

*Wholesale and retail gas markets.* Purchases of natural gas for further resale take place in the wholesale gas market. Purchases of natural gas for end use take place in the retail gas market. Wholesale transactions are all those concluded among producers, traders, suppliers, and pipeline and distribution companies; retail transactions are those between suppliers and end users.

The structure of wholesale and retail markets is important for the efficiency of pricing in them. Strong competition in these markets increases the economic efficiency of decentralized pricing and reduces the need for price regulation, while a lack of competition raises concerns about market power and price efficiency and calls for price regulation.

Each structural model of the gas industry has a different structure in its wholesale and retail markets and thus a different potential for the optimal pricing of natural gas (figures 6 and 7). Model 1 has a nonexistent wholesale market because all natural gas transactions are conducted internally by a single vertically integrated company that also monopolizes the retail market. Model 2 has limited competition in both the wholesale and the retail markets. Prices of natural gas in models 1 and 2 are regulated to prevent excessive pricing by the dominant gas utilities. Models 3 and 4 have relatively competitive natural gas markets, and model 4 has a more competitive transportation market than model 3.

*Long-term gas contracts and development of a spot market.* Gas contracts can be divided based on their duration:

- Short term—for supply of up to one calendar month.
- Medium term—for 1 to 12 months of gas supply.
- Long term—for more than one year.

Longer contracts become increasingly variable, because they reflect the specific requirements of each gas supply deal. Comparisons of long-term gas contracts are therefore complicated, because they must take into account so many dimensions.

Long-term supply contracts are the traditional way of acquiring gas. Utilities and their customers agree on prices and on the total volume of gas to be supplied over the life of the contract and then specify volumes for each year, quarter, or month. Long-term contracts reduce supply and price risks, but they provide little flexibility for adjusting supply and demand in response to changing market conditions. Pipeline companies often face excess demand during extremely cold weather, because gas prices do not reflect the short-term economic value of natural gas. Demand in peak periods is often controlled through administrative rules rather than prices, resulting in inefficient resource allocation.

Deregulation of the gas industry and greater flexibility in supply diminish the importance of long-term supply contracts and give rise to medium- and short-term contracts. In model 3 or 4 market participants need to balance their gas supply and demand in the short term. This need leads to the development of a spot market, where producers, traders, suppliers, distribution utilities, and large end users trade natural gas on a daily basis. Market participants enter into



contracts of different duration, building a contract portfolio that minimizes supply and price risks in both the long and the short run.

By generating price signals about the market value of natural gas, spot markets promote efficiency in the natural gas industry. A spot market usually develops in an area with a high concentration of buyers and sellers, such as at a pipeline interconnection near a large metropolitan area or at a terminal in a gas-producing region. The aggregation of supply and demand increases the liquidity of the market and boosts competition among market participants.

If there is competition among market participants, short-term (spot) prices follow the short-run marginal cost of natural gas. This means that the spot prices of natural gas reflect its economic value at a particular time and location (at the spot market), and market participants, facing efficient prices, can make optimal decisions about their trading strategies. But spot prices tend to be volatile because they change in response to changes in underlying factors of supply and demand, such as weather, available pipeline capacity, or consumption pattern. Market participants become exposed to this price risk because they are unable to predict the future price of natural gas. Their demand for tools to minimize price risk leads to the development of a financial gas market.

#### *Financial gas market*

The financial gas market is the marketplace where financial gas contracts are traded. A financial gas contract is used primarily for managing price risk and is not necessarily for physical delivery. Participants in the financial gas market come from all segments of the gas industry. Because transactions in this market involve the transfer of risks among these participants, intermediation plays an important role. The main intermediaries are traders and financial institutions, such as banks and organized exchanges.

Financial gas contracts are highly variable because of the heterogeneity of needs of market participants. The most common types of contract are forward contracts, swaps, futures contracts, and options.<sup>7</sup>

- A *forward contract* is a supply contract between a buyer and seller that obligates the buyer to take delivery, and the seller to provide delivery, of a fixed amount of a commodity at a predetermined price at a specified date. Payment in full is due at the time of or following delivery. (By contrast, for a futures contract settlement is made daily, resulting in partial payment over the life of the contract.)
- A *swap* is custom-tailored, individually negotiated transaction designed to manage financial risk, usually over a period of 1 to 12 years. Swaps can be conducted directly by two counterparties or through a third party such as a bank or brokerage house. The writer of the

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<sup>7</sup> The definitions of financial gas contracts draw on the U.S. experience. They are from U.S. Department of Energy 1995 and NYMEX [1996].

swap, such as a bank or brokerage house, may elect to assume the risk itself or manage its own market exposure on an exchange. Parties exchange payments based on changes in the price of natural gas, while fixing the price they effectively pay for physical delivery. The transaction enables each party to manage exposure to natural gas spot prices. Settlement is usually in cash.

- A *futures contract* is a represents a legal agreement between a party that opens a position on the futures market to buy or sell natural gas and the commodity exchange. The party agrees to accept or deliver, during a specified month, a certain quantity of natural gas meeting quality and delivery conditions described by the exchange. If delivery takes place, it occurs during the delivery month at a prescribed settlement price. Futures contracts are traded exclusively on regulated exchanges and are settled daily based on their current market value.
- An *options contract* gives its holder the right, but not the obligation, to purchase or sell the underlying futures contract at a specified price within a specified period in exchange for a one-time premium payment. The contract also obligates the writer, who receives the premium, to meet these obligations.

A financial gas market tends to develop once the physical gas market has reached a certain maturity and most natural gas is traded under short-term contracts. Since few countries have a liquid and mature spot market, the financial gas market is relatively new to the gas industry. Only the United States has a well-developed one.

Swaps and forwards are usually among the first financial gas contracts developed. They tend to be customer-specific contracts, developed by financial intermediaries and traders to suit the needs of individual clients—producers, distribution utilities, and large end users seeking to minimize the price risk they face in the physical gas market.

Demand for financial gas contracts increases as the physical gas market matures. The concentration of gas trading in spot markets facilitates the development of standardized financial gas contracts, such as futures and options contracts, that are developed and supplied by organized exchanges. For example, the New York Mercantile Exchange (NYMEX) and the Kansas City Board of Trade (KCBOT) in the United States have introduced standardized natural gas futures and options contracts for delivery in four major spot markets in the United States and Canada (see Juris forthcoming b).

Financial gas contracts serve two main purposes. They minimize the price risk in the natural gas spot market, and they minimize the basis risk resulting from the imperfect match between physical and financial gas contracts. They also serve as an instrument for speculation and price arbitrage in the gas market.

*Minimizing price risk.* Market participants minimize the price risk in the natural gas spot market by taking positions in the financial gas market, sometimes referred to as hedging. Financial contracts enable market participants to take positions in cash (or physical) and financial gas

markets to reach an acceptable level of risk. Different levels of risk aversion and the complexity of the gas market create room for market participants to engage in mutually beneficial transactions.

Transactions in the financial gas market involve the transfer of price risk between two market participants in exchange for payment. A market participant with high risk aversion is willing to pay a higher premium to get rid of a certain amount of price risk than a participant with low risk aversion. If the participant with low risk aversion can hedge against the price risk, it can acquire the price risk from the participant with high risk aversion. The two participants can then split the difference in premium, and both will be better off than if they minimized the price risk separately.

In practice, price risk cannot be diversified away completely because of systemic risk, the risk that is inherent to the market and cannot be diversified away. Market participants can diversify away only nonsystemic risk, that is, contract- or customer-specific risk. But this requires a sophisticated understanding of hedging strategies and the functioning of markets. The nonsystemic risk of a contract can be diversified away through a portfolio of cash and financial gas contracts that best approximates the market (that is, one that has coefficient beta equal to 1).

Gas traders and other intermediaries are much better able to diversify away nonsystemic risk than other market participants. They take nonsystemic price risks from producers, distribution utilities, and other market participants in exchange for premiums and then diversify these risks away by taking positions in physical and financial gas markets. The cost of hedging their positions is lower because they are less risk averse and more sophisticated in hedging strategies than other market participants. Competition among traders pushes premiums down to the least cost of price risk hedging and thus benefits all market participants engaged in financial gas transactions.

*Minimizing basis risk.* The use of financial gas contracts that differ in one or several dimensions from the underlying physical gas contract may result in a difference in the qualitative characteristics of contracted and delivered natural gas. This risk is the basis risk, the uncertainty about whether the cash-futures differential will widen or narrow between the time a hedge position is implemented and the time it is liquidated (NYMEX [1996]). The basis risk depends on three price relationships:

- The relationship between the price of the futures contract and the spot price of gas. This represents cash-futures basis.
- The relationship between the spot price at the futures contract delivery point and the spot price of a similar but not identical commodity at the same location. This is intercommodity basis.
- The relationship between the spot price at the futures delivery point and the spot price at a different location. This represents locational basis.

Strategies to minimize basis risk differ depending on the type of basis risk involved. Cash-futures basis risk can be minimized by a financial gas contract that specifically addresses the problems. For example, participants in the U.S. financial gas market use the Alternative Delivery Procedures, which allow them to minimize cash-futures price differentials in the period between the expiration date of a futures contract and the start of physical gas delivery. This period ranges from one to five days, depending on the type of futures contract.

Hedging intercommodity basis risk is a complex operation that varies from case to case, depending on the kind of commodities involved. If the commodities are commercially traded, market participants can minimize basis risk by taking positions in cash and financial markets in the relevant commodities. If qualitative differences in a commodity are very small and are not commonly traded in the market, such as the difference in the calorific value of natural gas, hedging tools may not be available. In such a case parties must protect themselves by explicitly defining delivery conditions and providing for penalties in the gas supply contracts.

Locational basis risk can be managed by a financial gas contract created specifically for this purpose. For example, participants in the U.S. gas industry can use Exchange of Futures for Physicals contracts (EFPs), which allow them to hedge the locational basis risk for almost any delivery location in the United States. Naturally, the efficiency of hedging by EFPs depends on the liquidity of EFPs with the same delivery locations, which in turn depends on the size and liquidity of the spot gas market at a particular location. As a result, EFPs provide effective hedging of locational basis risk only at the most commonly used locations, such as large market centers.

### **Transportation market**

A transportation market is a market where transportation services—pipeline capacity and natural gas shipments for delivery of natural gas to a desired location—are sold in the form of transportation contracts. The contracts are sold by pipeline companies to shippers. Transportation contracts are either firm or interruptible, depending on the reliability of the services they offer. Holders of firm transportation contracts may resell them in the secondary transportation market if regulation permits such transactions.

The transportation market emerges only in the model 3 natural gas industry, where pipeline companies offer open access to their pipeline grids. The market develops further with unbundling and the introduction of retail competition. Model 4 has a fairly developed transportation market, where industry participants trade transportation contracts for gas shipments in all pipeline grids.

#### *Primary transportation market*

The primary transportation market facilitates the initial distribution of transportation contracts. The contracts give the shippers that buy them the right to transportation services under the conditions specified. The most common conditions relate to the size of reserved capacity, the size of natural gas shipment, the location of points of injection and withdrawal, pipeline pressure, the time and duration of service, service reliability, and charges for capacity and throughput.

Characteristics of service determine the structure of the contracts, with the most important being duration and reliability. Duration-based transportation contracts are divided into long-, medium-, and short-term contracts, linking them to the duration of gas supply contracts and facilitating simultaneous clearing of natural gas and transportation markets in an unbundled natural gas industry.

Reliability-based transportation contracts can be divided into two major categories: firm and interruptible. A firm transportation contract gives its holder the right to capacity and transportation over the whole life of the contract, regardless of the season. It specifies the maximum daily quantity of gas that can be transported through the pipeline, points of injection and withdrawal, and charges for reserved capacity and transportation service. The holder of the contract can ask for shipment of natural gas up to the maximum reserved capacity (capacity utilization is measured by the load factor, calculated as the ratio of average daily capacity usage to the maximum daily reserved capacity). This request is usually made through notification of the pipeline company about the volume of natural gas to be shipped on the next day, or “nomination.”

An interruptible transportation contract gives its holder the right to ship a specified volume of natural gas within a certain period, for example, within a particular month. But the timing of transportation is determined by the pipeline company according to the availability of capacity.

There are also hybrids of firm and interruptible contracts, such as no-notice or limited firm transportation contracts. A no-notice firm transportation contract gives its holder the right to the maximum daily reserved capacity, but the holder does not have to maintain a daily balance between nominated and delivered natural gas. A limited firm transportation contract offers firm transportation service, but the service is subject to interruption for a specified amount of time each month, say, up to 10 days.

The primary transportation market is regulated because of the natural monopoly characteristics of pipeline transportation (see the section above on the determinants of industry structure). Governments often regulate prices, investment, contracts and delivery conditions, and market access.

The nature of contracting for transportation services varies with industry structure and regulation. Vertically integrated natural gas companies typically offer long-term firm transportation contracts that specify the total volume of gas to be delivered to the users over the life of the contract. Users then specify monthly or quarterly deliveries that must add up to this total contracted volume by the end of the contract. Long-term contracts give pipeline companies and shippers certainty in demand and supply, and they give pipeline companies the ability to recover their fixed costs through revenues from contracted capacity.

Deregulation of natural gas markets creates a need for flexible transportation services. Market participants need to balance supply and demand in the short term, which is possible only if a natural gas supply contract is matched by a transportation contract in all major dimensions.

Pipeline companies respond to this need by offering medium- and short-term transportation contracts and flexibility in the choice of injection and delivery points. This response must be facilitated by a regulatory change introducing a more flexible regulatory environment for the pipeline companies and creating a secondary transportation market. For example, in 1992 the U.S. Federal Energy Regulatory Commission required all pipeline companies to provide more delivery and injection points in their pipeline systems and offer their customers no-notice, balancing, and storage services. It also changed the formula for calculating transportation rates and introduced the capacity release program, a secondary market with firm transportation contracts.

### *Secondary transportation market*

Holders of unused transportation contracts resell them in the secondary transportation market. Buyers and sellers in this market come from all segments of the gas industry, although pipeline companies are typically excluded because of market power concerns.

The resale of transportation contracts promotes the efficiency of the transportation market and facilitates simultaneous clearing of natural gas and transportation markets. The need to resell contracts arises as a result of short-term changes in supply and demand for individual users which often lead to a situation in which some users do not utilize all their contracted pipeline capacity while others lack sufficient capacity to meet their needs. In the absence of a secondary market, the unused capacity lies idle, with the result that resources are wasted and trade opportunities lost. In addition, potential buyers lose the benefits of having more natural gas available at their desired location. Allowing the resale of transportation contracts therefore benefits the entire natural gas industry.

If transportation contracts establish property rights and are transferable, holders can trade them freely (though notification of the pipeline company about the change of contract ownership may be required) and the secondary market flourishes. Firm capacity contracts that give their holders the right to reserved capacity may be transferable, for example, depending on the prevailing regulation.

If transportation contracts establish property rights but are not transferable, holders can engage in a side deal, delivering natural gas for a third party. The owner of the natural gas pays a transportation fee to the contract holder, who in turn pays the pipeline company the rate specified in the contract. The secondary market exists, but the complicated trading procedures harm market efficiency because high transaction costs discourage some users from trading their unused capacity.

If transportation contracts do not establish property rights, they cannot be traded, and the secondary market does not exist, at least officially (but shippers can still engage in side deals to match their natural gas and transportation contracts, as in the case of nontransferable transportation contracts). This is the worst possible case because the potential benefits of capacity resale are not realized.

Regulation of the secondary transportation market is unnecessary if there is competition among buyers and sellers of transportation contracts. The price of a firm transportation contract resold in a competitive secondary market should reflect the short-run marginal costs of pipeline operation and the opportunity costs of capacity. This pricing mechanism allows the prices of capacity and shipping services to adjust to changes in short-term supply and demand. Thus, for example, prices for pipeline capacity would be high during peak periods, when demand exceeds supply, but approach zero during periods of excess supply. By contrast, the price for shipping natural gas would be relatively low and constant because of the relatively low and constant marginal operating costs.

Secondary trading of transportation contracts can take several forms. A typical trading arrangement is an auction where interested shippers bid by price for available transportation contracts. Auctions are used for trading both long- and short-term transportation contracts, though rigorous auction procedures sometimes discourage resale of short-term contracts because of the time requirements.

Another common form of trading is bilateral dealing. This form of trading facilitates the resale of all types of transportation contracts because it gives shippers much flexibility in negotiating the conditions of transactions.

Trading may also take place in a spot market, where shippers actively trade short-term transportation contracts. Spot market trading requires standardizing transportation contracts across all important dimensions in order to promote efficient pricing of the contracts. It also requires other characteristics of a liquid spot market, such as a large number of buyers and sellers, large available capacity, and the concentration of trading in one or several locations. An active spot market for transportation contracts provides scope for a financial transportation market, where market participants can minimize the price and basis risks in the transportation market.

### **Markets in other segments of the gas industry**

Increasing deregulation and restructuring of the natural gas industry leads to the emergence of markets in other segments of the industry. Unbundling and open access, for example, give rise to markets in natural gas storage, metering and installation of meters, construction of pipelines, and pipeline system balancing.

#### *Storage*

Unbundling pipelines gives natural gas storage a new role in natural gas and transportation markets in addition to its traditional role of load balancing.<sup>8</sup> As a natural gas industry moves toward structural model 4, storage is deregulated and storage operators become active in the gas

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<sup>8</sup> Load balancing preserves the balance between injections and withdrawals of natural gas in the pipeline system.

market, buying and selling natural gas as market conditions change. Storage can be crucial in relieving pipeline congestion in local gas markets and helping to lower gas prices.

Deregulation of gas prices and the gas market creates plenty of profit opportunities for storage facilities. Profit-maximizing storage operators look for markets where prices are high because of a lack of competition or frequent congestion of the pipeline system. A storage facility can increase competition in a local market because it becomes another player in the market, giving other market participants another choice in selecting a supplier or buyer. And the success of one storage facility can attract more operators, further increasing competition.

Deregulating storage operations can help relieve pipeline congestion. In a local gas market high seasonal variation in natural gas prices may reflect pipeline capacity constraints in peak periods. A storage operator can use the available pipeline capacity in off-peak periods, when natural gas prices are low, to inject natural gas into storage, and then sell this gas in the local market for higher prices during peak periods. The storage operator reaps the benefits of high peak prices, but it also pushes peak prices toward competitive levels because the availability of natural gas from storage relieves congestion, at least partially. And its high profits will attract additional storage facilities to the market, which will further lower prices.

But storage operators face two major problems in deregulated gas markets. The first is linked to volatile gas prices, which introduce much uncertainty into decisions about the size and location of a storage facility. Since most storage profits come from location- and time-based price arbitrage, being able to predict future prices is crucial. Storage operators benefit greatly from price discovery in the financial gas market, which provides efficient signals about future natural gas prices. If the financial gas market is not developed, storage operators can reduce price uncertainty by signing a long-term supply or purchase contract.

The second problem is linked to regulation of storage. Despite its increasing commercialization, storage still serves as a tool to balance load in the pipeline network. If a storage facility serves both functions, it becomes subject to regulation because of its link to the regulated pipeline transportation segment. But distinguishing the costs associated with load balancing from the costs associated with regular commercial operation is difficult, so determining the charges for load balancing is a complicated and imprecise exercise. The remedy is to create a balance market, where a pipeline company trades system imbalances with other participants in the gas market (see the section below on the balance market).

#### *Metering and installation of meters*

A market in metering emerges as a result of the introduction of retail competition in model 4. Metering becomes an important element in retail competition because suppliers must know how much natural gas each consumer uses. Initially, all metering facilities are controlled by a distribution company. But independent suppliers, fearing that the distribution utility will exercise market power and provide low-quality metering services, will demand independent metering services. An opportunity is thus created for new entrants to install new meters or take over old ones, and to sell metering services to independent suppliers, distribution utilities, and end users.



Independent metering is limited by the costs of metering and installation, however. Suppliers and end users will probably find that the costs of metering at residential sites outweigh the potential savings because of the prohibitive costs of new metering devices and the low potential benefits. Independent metering has developed mainly for large and medium-size consumer sites, while small sites are still served predominantly by distribution utilities. Only the introduction of low-cost metering technology can promote increasing use of independent metering and eliminate the ability of distribution companies to restrict retail competition through inferior metering.

### *Construction of pipelines*

A market in construction of new pipelines emerges when deregulation of pipeline transportation allows construction and operation of natural gas pipelines by third-parties. This decentralized pipeline expansion regime can be introduced in structural models 3 and 4. (A centralized regime allows pipeline construction only by pipeline companies.)

New pipeline capacity is added when market participants find it more beneficial to construct new capacity than to pay a congestion rent. Under a decentralized regime a pipeline company operates as a contract carrier and does not have an obligation to construct new capacity. If demand grows beyond available capacity in a location, market participants will face high spot prices for natural gas in that location because of the resulting congestion. Once the expected present value of congestion payments (congestion rent paid to a pipeline company or congestion premiums paid to gas traders) exceeds the present value of the costs of constructing and operating a pipeline, market participants will add to pipeline capacity.

Three important factors affect the efficiency of the decentralized capacity expansion regime. First, locational spot markets must be liquid and deregulated to generate efficient signals about the market value of natural gas. An efficient spot market enables market participants to estimate the congestion rent in a particular location by comparing spot market prices among locations.

Second, charges for transporting natural gas between locations should not distort locational spot pricing of natural gas. Regulation of transportation rates must ensure that all participants in the gas market face the same rates for transportation if they demand qualitatively and quantitatively identical services. In addition, regulators should promote trading in the secondary transportation market because it facilitates efficient pricing of pipeline capacity and reveals information about the size of the congestion rent.

Third, cooperation between new and incumbent pipeline companies is important to promote functional integration of their pipelines. If two pipelines fail to coordinate their transportation services, transactions between participants connected to the different pipeline systems will be difficult. So, to ensure efficiency, the incumbent pipeline company and an independent pipeline operator should agree on a mechanism to facilitate transactions through their pipeline interconnection.

To increase revenues and reduce average costs, an independent pipeline operator should consider providing open access to its pipeline to parties that did not participate in the pipeline's construction. Benefits from operating a pipeline can be distributed among its owners on the basis of their contributions to the construction costs. If the new pipeline experiences congestion in the future, the pipeline owners can more than recover their investment through congestion rents.<sup>9</sup>

### *Balance market*

A balance market is a market where pipeline system imbalances are traded through an auction. A system imbalance arises when there is a difference between the volume of gas flows and the available capacity in the pipeline system. A system imbalance can occur any time that shippers do not maintain their individual balances—the balances between their nominated and actual gas shipments. The balance market can first appear in model 3 or 4, but so far its practical implementation has been limited to the United Kingdom. A balance market was created there in 1996, when British Gas was unbundled into a gas supplier and a pipeline system operator.

The balance market is closely linked to the operation of the pipeline system. A pipeline operator must maintain a balance between injected and withdrawn natural gas to ensure the safety and reliability of transportation services. The operator achieves a balance by scheduling gas flows for the following day on the basis of shippers' nominations, the information shippers provide about desired directions and volumes of shipments. The operator then runs the pipeline system according to the schedule and monitors injections and withdrawals in real time.

But before the gas day, the pipeline operator invites shippers to bid for system imbalances. The imbalances can be positive or negative, depending on whether there is an excess or shortage of natural gas in the system. Shippers send bids stating how much gas they are willing to buy or sell if a system imbalance occurs, and at what price. If the system runs into an imbalance, the operator determines how much natural gas it must buy or sell to restore balance and then accepts the bids that do so at the lowest total cost. The operator pays the winning bidders a price equal to the price of the last bid accepted. If the bidding for system imbalances is competitive, this price reflects the system's short-run marginal cost of gas.

An efficient balance market produces information with wide utilization in the deregulated gas industry. The prices generated by the balance market can be used for pricing the load balancing services provided by storage facilities to pipeline companies. The price of a system imbalance reflects the costs that the imbalances of individual shippers imposed on the pipeline system, so the pipeline operator knows exactly how much it must recover from undisciplined shippers. Finally, the cost of restoring system balance signals the pipeline operator when to use the balance market and when to curtail gas flows.

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<sup>9</sup> Whether pipeline sources can recover their investment congestion rents depends on the type of regulation of transportation charges. A pipeline operator can earn congestion rents only if it can charge prices based on the short-run marginal cost of transportation. See Harvey, Hogan, and Pope, 1996.

## **Trading Models in the Deregulated Natural Gas Industry**

Trading mechanisms guide transactions in natural gas and transportation markets. They facilitate interactions among market participants with the objective of achieving simultaneous clearing of natural gas and transportation markets at minimum cost to the gas industry.

Deregulation of the natural gas industry leads to separate trading of natural gas and transportation services, which increases the complexity of markets and imposes substantial requirements on market participants if they are to complete all their transactions at the minimum cost. While a vertically integrated gas company optimizes all transactions internally, participants in a deregulated gas industry must coordinate their natural gas and transportation transactions in an open market. The process of minimizing the total cost of natural gas and transportation to the industry must take place across thousands of decentralized transactions. Unless these transactions are guided by a trading model, they can result in suboptimal allocation of resources.

Two distinct trading models have been developed: a bilateral trading model and a poolco model. Both models achieve market clearing at the minimum cost, though in different ways. The main differences between the models are in the nature of transactions and in the way the transactions are coordinated in natural gas and transportation markets.<sup>10</sup>

### **Bilateral trading model**

The bilateral trading model is based on decentralized bilateral transactions. The model relies on competitive gas and transportation markets to generate efficient prices and minimize the cost of natural gas to the end users.

#### *Decentralized spot markets*

In the bilateral trading model market participants conclude all deals in bilateral negotiations and write contracts that address all issues relevant to a transaction. Demand for ways to minimize of transaction costs leads to the emergence of traders who complete transactions on behalf of other market participants. Spot markets develop as market participants require efficient pricing of natural gas at every moment. Spot markets are thus developed through the decentralized action of market forces.

Competitive spot markets generate signals about the market value of natural gas and give market participants the right incentives to complete transactions efficiently. As a result, decentralized bilateral trading among market participants achieves the outcome that is optimal for individual participants as well as for the natural gas industry as a whole.

#### *Distance-based pricing of transportation*

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<sup>10</sup> The following sections draw heavily on the excellent discussion of trading models in Hunt and Shuttleworth 1996.

Charges for transportation services sold in the primary transportation market are based on the fixed and variable costs of a pipeline company per unit of distance over which individual shipments take place. A capacity charge is set to recover total fixed costs, while a throughput charge is used to recover the variable costs of transporting natural gas. Transportation contracts sold in the secondary market are priced according to the short-run marginal cost of capacity.

A competitive secondary capacity market and the availability of many different firm and interruptible transportation contracts enable shippers to match their needs for natural gas with transportation services. They form a portfolio of transportation contracts that gives them the minimum acceptable reliability of transportation at the minimum cost. Because each shipper is able to minimize its total cost of natural gas and transportation, the total cost of natural gas to end users is minimized.

#### *Direct access in retail competition*

In the bilateral trading model retail competition takes place among suppliers who compete by price for power supply contracts. End users can choose a supplier of natural gas, which is then responsible for arranging transportation of natural gas to the consumption site. This structure, in which end users enter into supply contracts with suppliers, is referred to as "direct access."

Suppliers charge end users a single price for a unit of delivered natural gas. Competition among suppliers ensures that the retail price is equal to the sum of the wholesale gas price plus the distribution fee. Since suppliers have the ability to acquire natural gas and transportation services at the minimum cost, end users face optimal retail prices. So all transactions in the natural gas industry lead to the socially optimal outcome.

#### **Poolco model**

In the poolco model transactions are coordinated by a single entity, which ensures that all transactions in natural gas and transportation markets are completed at the minimum cost to society. The poolco model is based on the notion that decentralized bilateral transactions do not always lead to the socially optimal outcome in the gas industry because of the technical characteristics of natural gas pipeline systems.<sup>11</sup>

#### *Pool operator*

Transactions in the natural gas market are facilitated by a pool operator, an entity assigned a market clearing responsibility by the regulator. Market participants inform the pool operator how much natural gas they want to purchase or sell and at what prices they are willing to complete

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<sup>11</sup> This argument is taken from the context of the electric power industry. Like an electric power transmission grid, a natural gas pipeline system exhibits network externalities that affect loads in two separate locations. A gas shipment from one location can reduce the capacity available to shippers in an adjacent interconnected pipeline. However, the operator of a pipeline network has more options for controlling loads and flows in real time than the operator of a power transmission grid.

transactions. The pool operator aggregates this information into system supply and demand and calculates the system price that will clear the market. This procedure is repeated at short intervals to generate continuous pricing of natural gas.

The pool operator can divide the natural gas market into several local markets (nodes) if there is insufficient pipeline capacity to move natural gas between locations. It would then determine prices for each node using the same procedure.

The system price reflects the market value of natural gas. Competition among natural gas suppliers and buyers ensures that system prices reflect the short-run marginal costs of natural gas—that is, that they are efficient. Because all market participants complete transactions at system prices or their derivatives the outcome of trading under the poolco model is socially optimal.

#### *Locational pricing of transportation*

Transportation is sold as a service that takes natural gas in or releases it from the pipeline system at a particular location. Shippers buy entry and exit capacity at points of injection and withdrawal from a pipeline company or other shippers. They order transportation services by nominating the volume of natural gas they want to ship through the pipeline system on the next day. A pipeline company reviews the nominations of all shippers and determines the schedule of gas flows that minimizes the total cost of transportation. If some capacity remains after the nominations of firm shippers have been accounted for, the pipeline company offers interruptible services to other shippers. Gas flows in the pipeline system do not always follow the “contractual paths” because a pipeline company can often find a more optimal way to direct flows through the system.

The prices of transportation services are based on the market value of capacity and throughput at the entry or exit point and thus reflect the short-run marginal cost of capacity and throughput. Prices vary in time and across locations, reflecting differences in the market value of capacity (the marginal cost of throughput tends to be small and constant). A pipeline company determines the value of capacity as the difference between nodal prices of natural gas, because this difference reflects the congestion rent earned by a congested pipeline. Competitive local gas spot markets generate efficient signals about the size of the congestion rent, ensuring that shippers pay efficient prices for transportation services and can make optimal transactions in natural gas and transportation markets.<sup>12</sup>

#### *Virtual access in retail competition*

Under the poolco model retail competition takes place among suppliers who compete by price for financial gas contracts. End users receive physical delivery of natural gas from the local distribution utility, which charges only for transporting the gas through distribution pipelines and

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<sup>12</sup> But shippers face price risk in the transportation market if capacity prices are based on the short-run marginal costs. To enable shippers to minimize price risk, a financial transportation market must be created .

fully passes through the prevailing nodal price of gas to the end users. As a result, end users face spot prices, but they cannot choose another gas supplier, a structure referred to as “virtual access.”

End users are exposed to price risk because they face volatile spot prices. Suppliers therefore sell them insurance plans—financial gas contracts that stabilize retail prices by minimizing price risk—and end users choose among suppliers based on the insurance premiums. Competition among suppliers ensures that premiums are efficient, reflecting the risk aversion of end users and the costs of hedging. Because end users face both efficient spot prices for natural gas and efficient insurance premiums, the outcome of all transactions in the natural gas industry is socially optimal.

### **The bilateral versus the poolco model in the natural gas industry**

If properly applied, the bilateral and poolco trading models both lead to the same outcome. Which model is more appropriate for a country depends on the characteristics of its natural gas industry. Countries with relatively large gas markets can rely on the decentralized actions of market forces to develop a liquid and competitive spot market and could therefore opt for the bilateral model. Smaller countries may find it necessary to speed up the development of a spot market by establishing a pool operator that facilitates market clearing in the gas and transportation markets.

The structure of a pipeline system also affects the choice of trading model. Pipelines with a trunk line structure are ideal for the bilateral model because network externalities are small. By contrast, a pipeline system structured as a dense network exhibits network externalities because loads in one line affect loads in another one. And since bilateral transactions do not take into account load interdependencies, market participants can require transportation services that do not minimize total transportation costs. In this case, then, the poolco model is more appropriate, because it allows the pipeline operator to determine the optimal gas flow schedule regardless of contractual paths.

Transactions in the bilateral trading model are relatively simple. Because they are bilateral, they are easy to complete and understand even in complex markets. By contrast, transactions in the poolco model place enormous information requirements on the pool operator, which must have access to information about the availability, prices, and costs of natural gas and transportation. As a result of these information requirements, the prime candidate for the job of pool operator is a pipeline company, which has the best information about the pipeline system—information difficult to obtain in a decentralized market. An alternative candidate is an independent entity jointly owned by all participants in the gas industry. In such a case, the pool operator must establish confidentiality rules to ensure all participants that sensitive information will be well protected.

Application of these two trading models in the natural gas industry has been uneven. Almost all countries have opted for the bilateral trading model, because it is simpler to implement than the poolco model. In these countries, natural gas trading takes place primarily as a bilateral

transaction in decentralized spot markets and retail competition, if introduced at all, is based on the direct access scheme, in which end users conclude physical gas contracts with suppliers. The poolco model has been applied only in the United Kingdom, and there only to a limited extent.

A typical example of the bilateral trading model exists in the gas industry in the United States, where natural gas spot markets have developed as a result of deregulation during the past six years. Resale of transportation contracts has led to the development of a secondary transportation market and promoted variability in transportation contracts. Trading takes place on a bilateral basis in a competitive market. Transaction costs are minimized through the use of natural gas marketing companies and electronic trading systems that aggregate information about the availability and prices of natural gas and transportation across regions. Competition and transparency in the gas and secondary transportation markets promote efficient pricing of natural gas and transportation contracts. And because market participants can coordinate transactions in both natural gas and transportation markets, they can minimize their total cost of natural gas and transportation.

In the limited version of the poolco model in the U.K. gas industry, British Gas TransCo, a pipeline system operator, optimizes gas transportation regardless of the contractual paths. It has organized a spot market for natural gas, called the “on-system” market, and a spot market for system balances, the “flexibility” market. All other transactions in the gas industry are completed on a bilateral basis.

British Gas TransCo optimizes gas flows through the pipeline system on the basis of the principle of minimizing total transportation costs. Shippers purchase entry and exit point capacity and notify the operator about the volumes and locations of injection and withdrawal. The optimal transportation schedule determines gas flows regardless of the transactions by shippers in the natural gas market.

On-system trading takes place among shippers when they exchange ownership of natural gas that has been injected into the pipeline system. The pipeline system operator plays the role of a “natural gas exchange” to facilitate natural gas transactions, but it does not determine the system price of natural gas. Instead, prices are set by market participants in decentralized bilateral negotiations. On-system trading therefore combines the bilateral and poolco trading models.

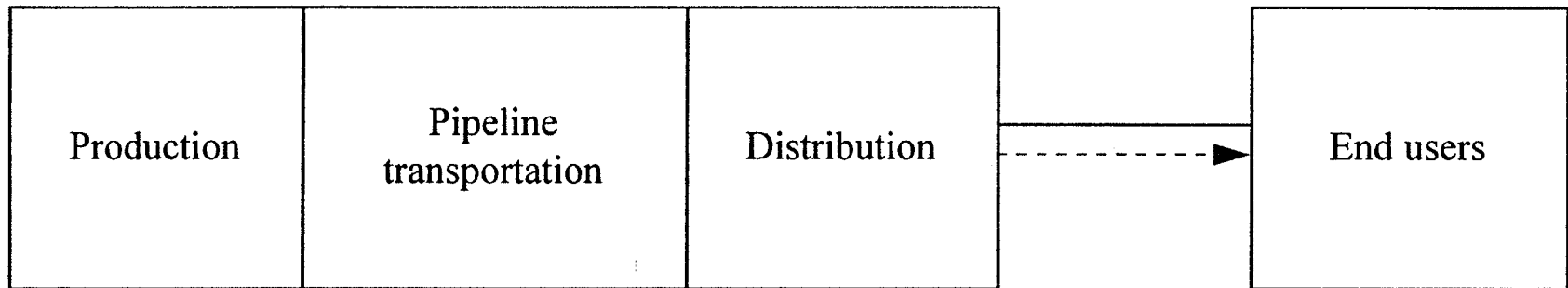
In the balance, or flexibility, market, which is representative of poolco-style gas trading, the operator receives bids for sale or purchase of natural gas from other market participants. If the pipeline system experiences an imbalance, the operator accepts the bids that minimize the cost of restoring system balance. Shippers whose bids are accepted are paid the system price that is equal to the price of the last bid accepted (see Juris forthcoming a).

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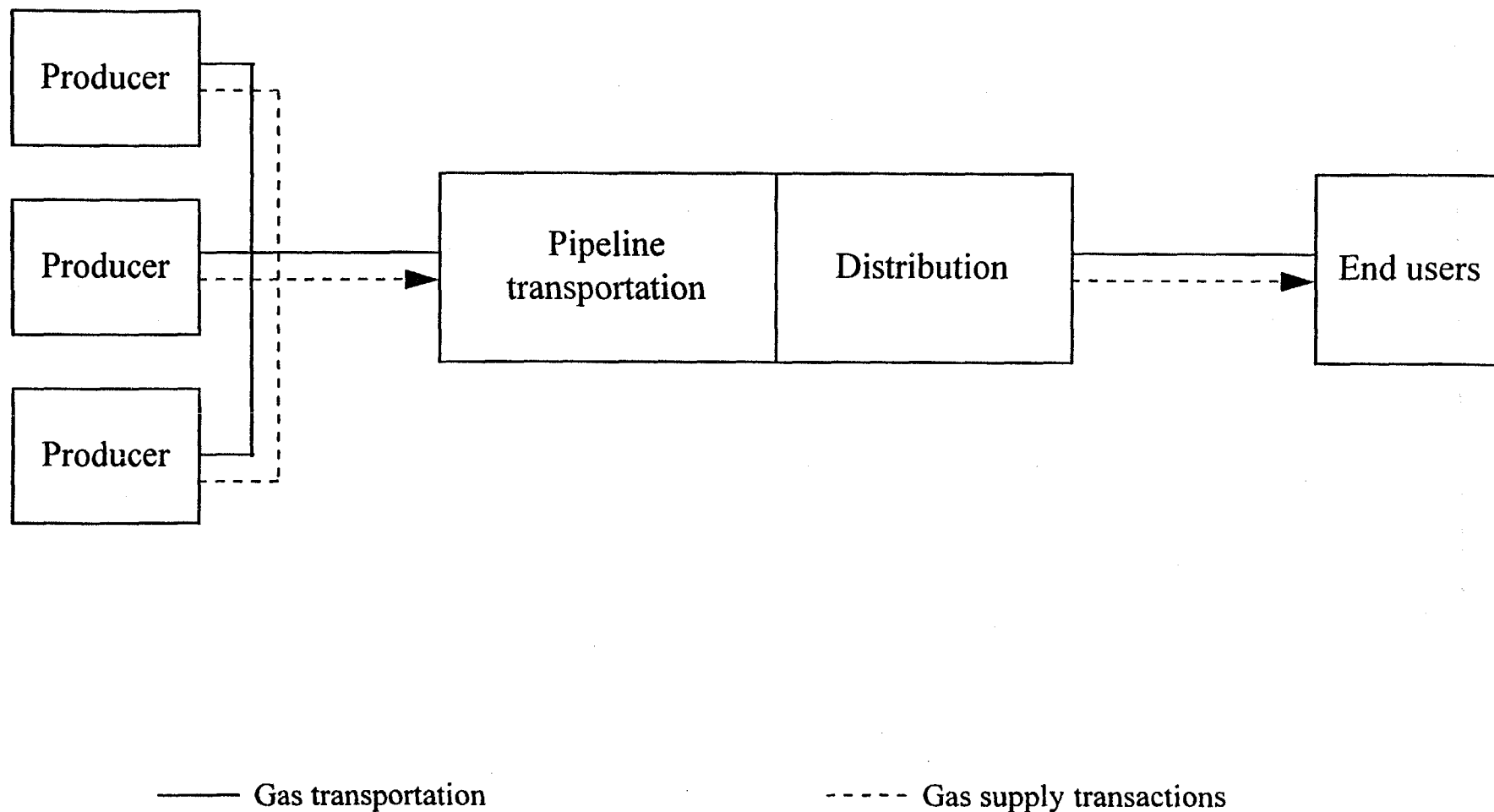
**Figure 1 Model 1: Vertically Integrated Natural Gas Industry**



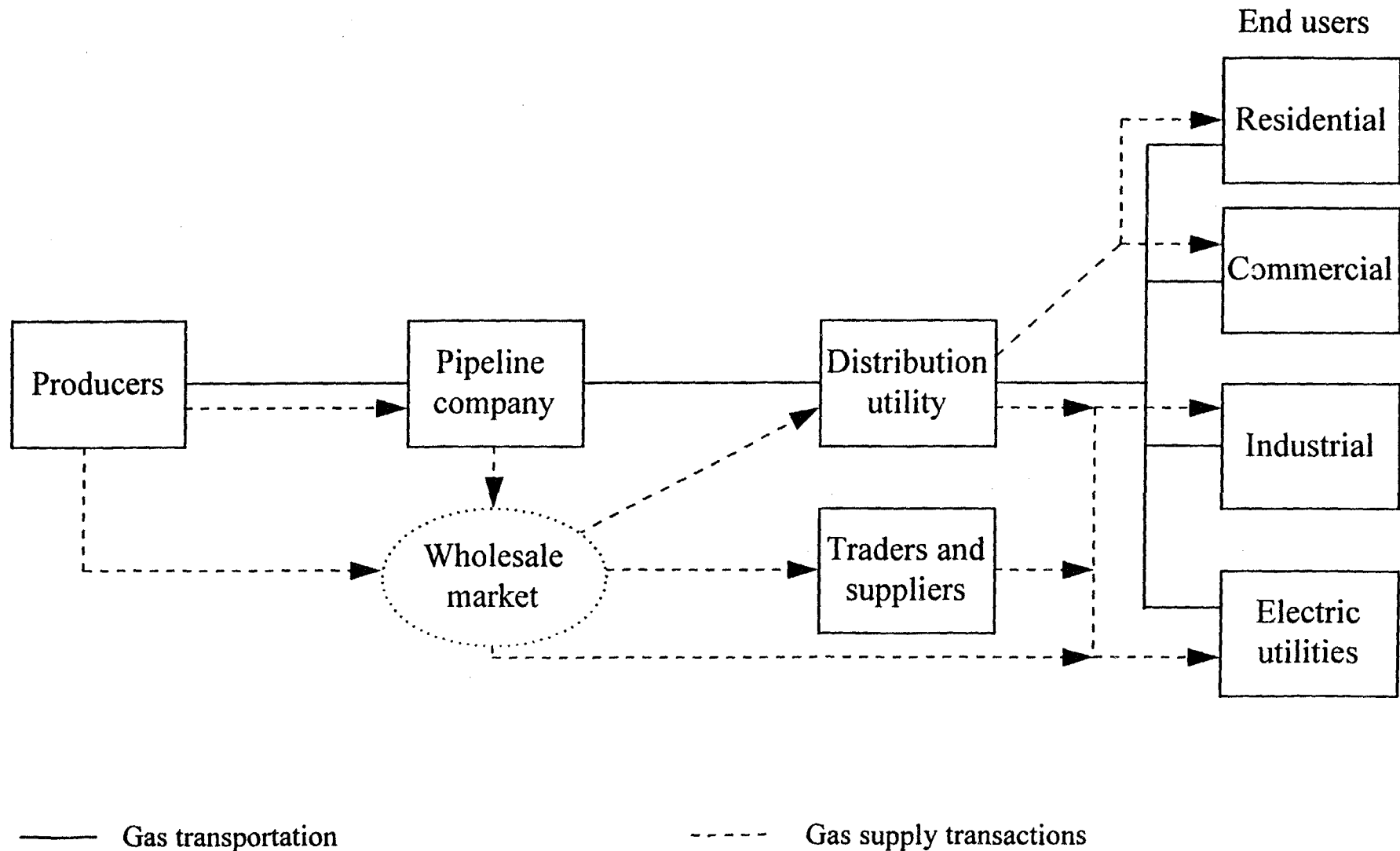
———— Gas transportation

----- Gas supply transactions

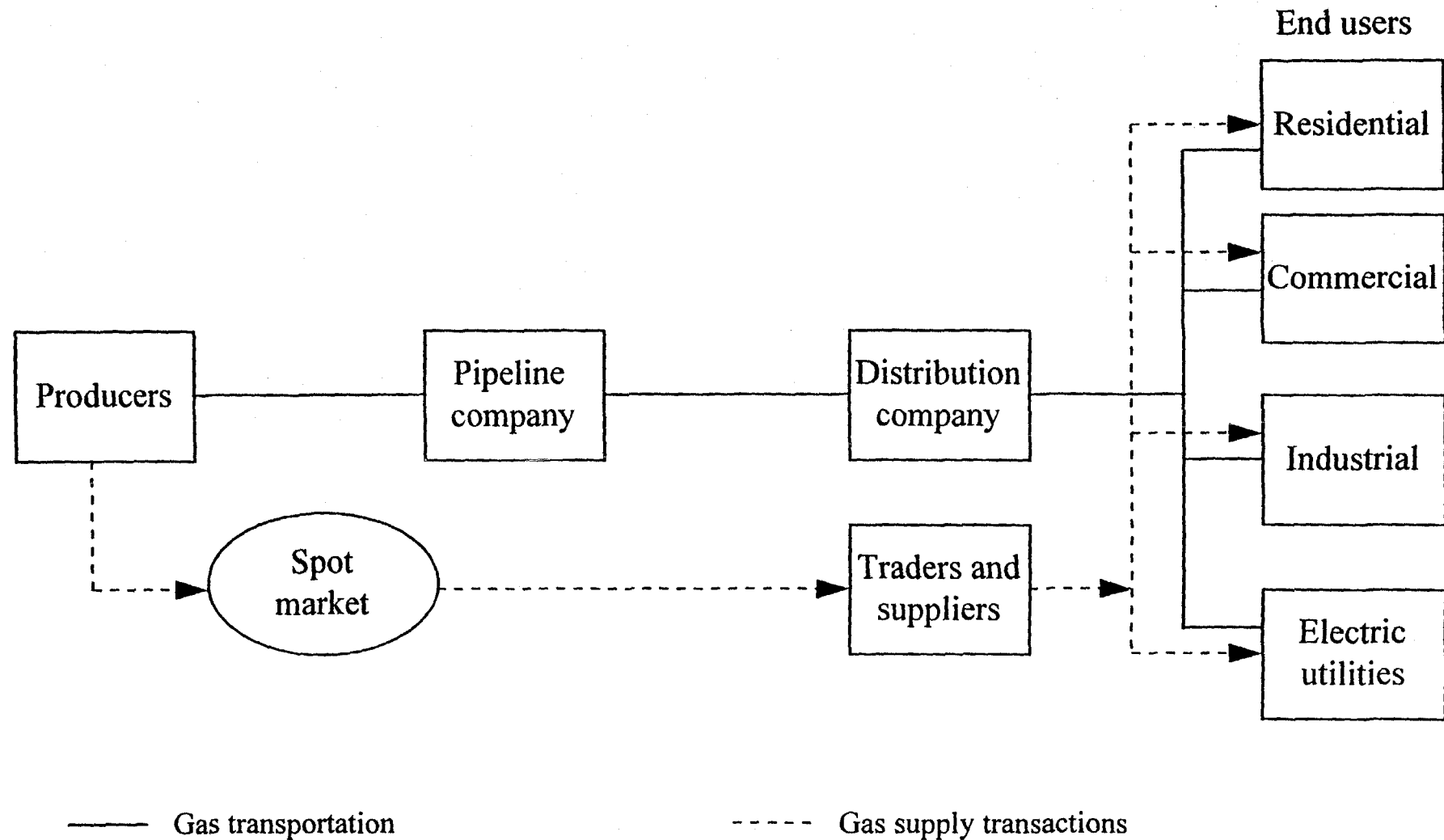
**Figure 2 Model 2: Competition among Natural Gas Producers**



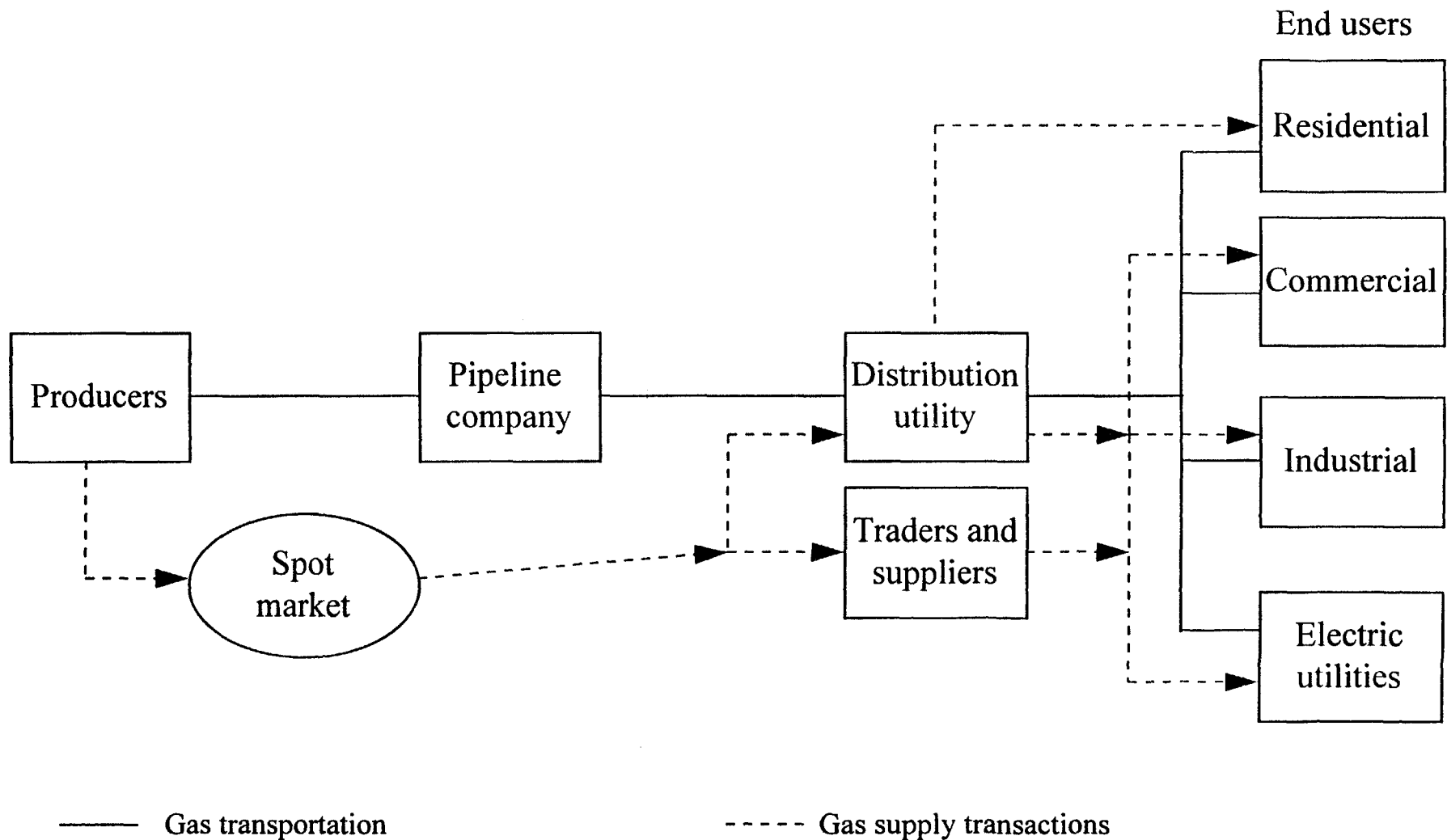
**Figure 3 Model 3: Open Access and Wholesale Competition**



**Figure 4 Model 4: Unbundling and Retail Competition**

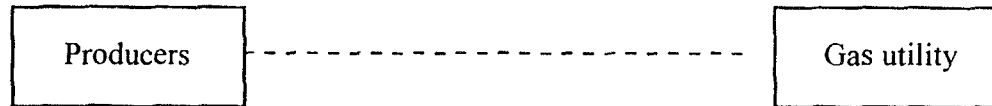


**Figure 5 Transitional Model: Unbundling of Pipeline Transportation and Open Access to Distribution**

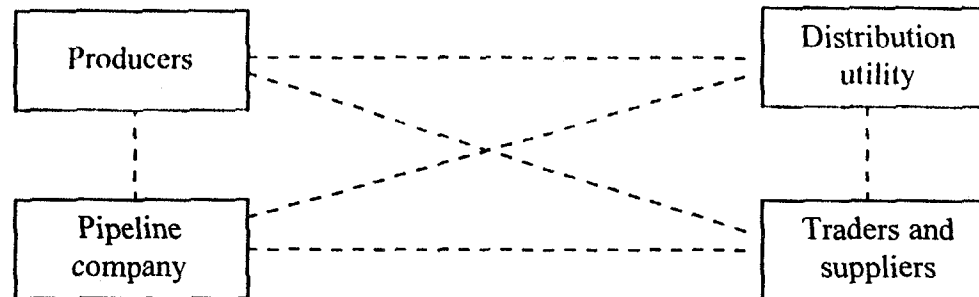


**Figure 6 Structure of the Wholesale Gas Market**

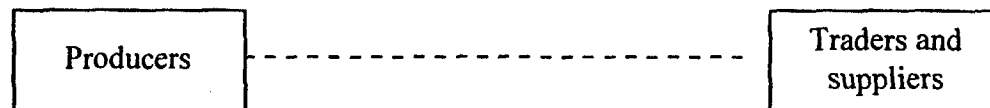
**Model 2**



**Model 3**

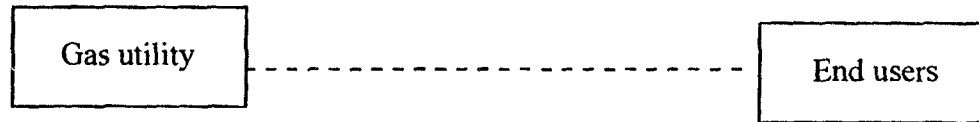


**Model 4**

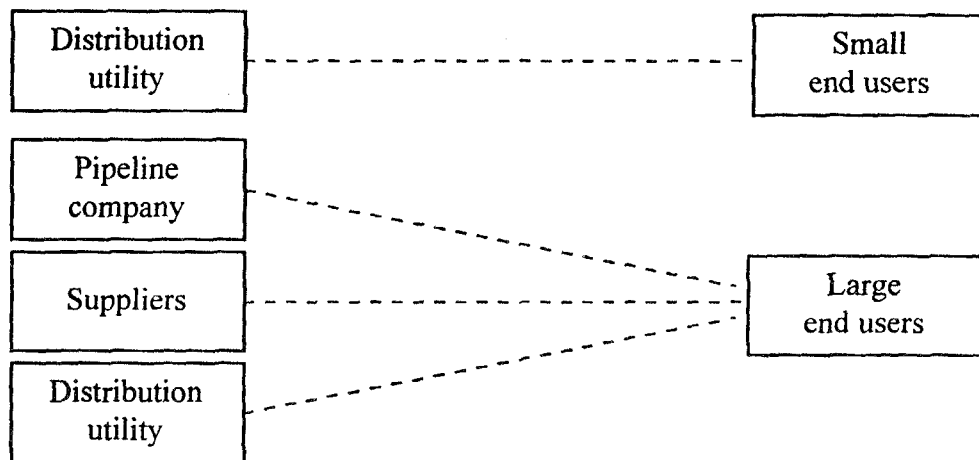


# Figure 7 Structure of the Retail Gas Market

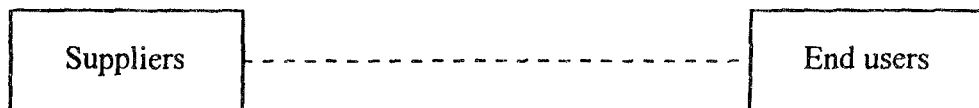
## Models 1 and 2



## Model 3



## Model 4



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